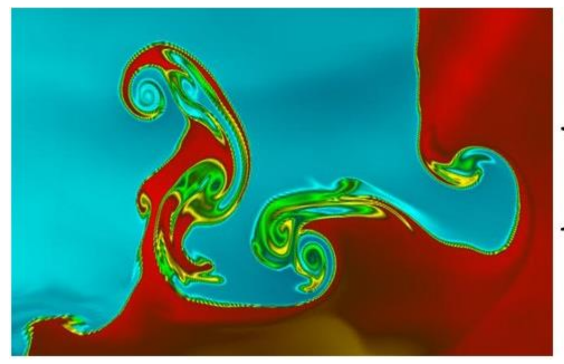

FMSTL

Exploring Rayleigh-Taylor Mixing in a Convergent Geometry

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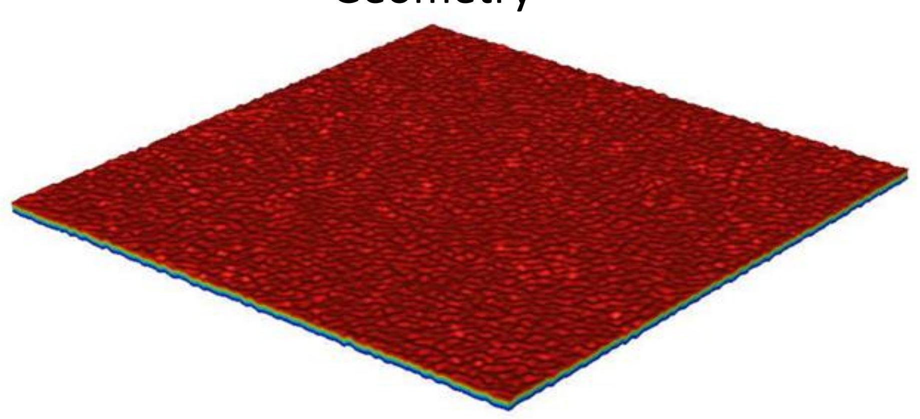
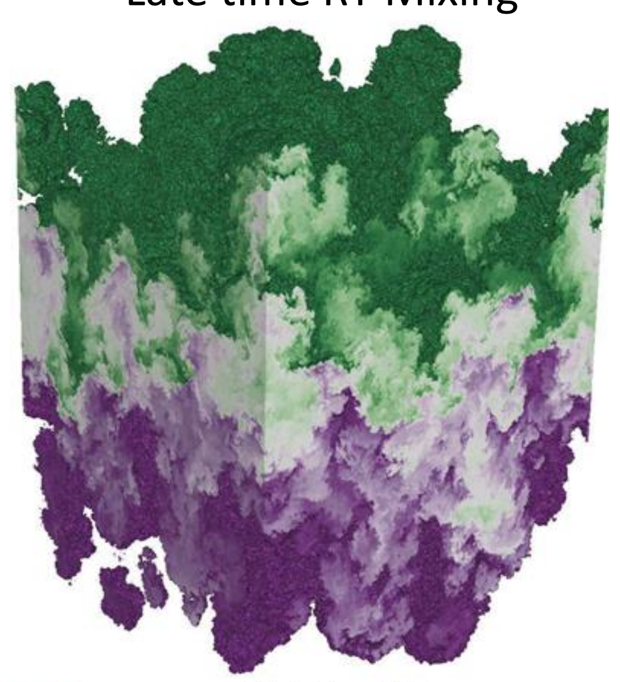
Introduction

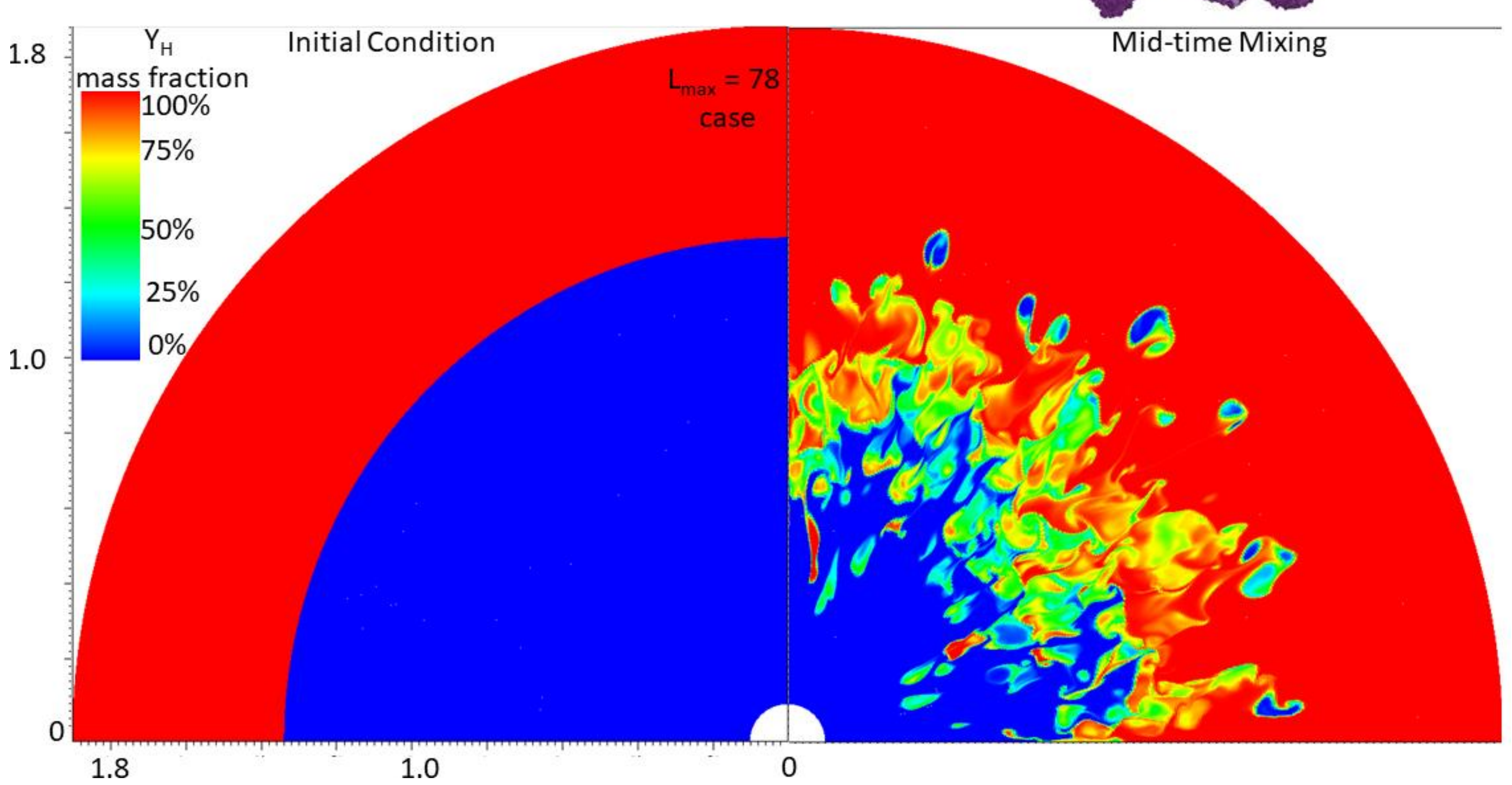
The Rayleigh-Taylor (RT) instability is a common instability encountered in high energy density physics. One such example is the Inertial Confinement Fusion (ICF) experiments performed at the National Ignition Facility, where the RT encourages mixing between the heavy ablator material and the light hydrogen fuel. This mixing, driven by an acceleration vector which acts opposite the perturbed density gradient provided by the ablator and fuel degrades capsule performance. This work expands upon earlier work on a multimodal planar RT configuration by considering a convergent geometry. In this geometry the constant acceleration is provided as 100 times earths gravity and acts on a perturbed interface with a heavy fluid (denoted Y_H) shell surrounding a body of light fluid. It is expected that the converging geometry will be effected by the Bell-Pesset effects which can lead to the transition phase earlier. The ARES hydrocode was used to study this problem. It is formally second order and utilizes adaptive mesh refinement.

Initial Conditions for Planar Geometry[1]



Late time RT Mixing[1]



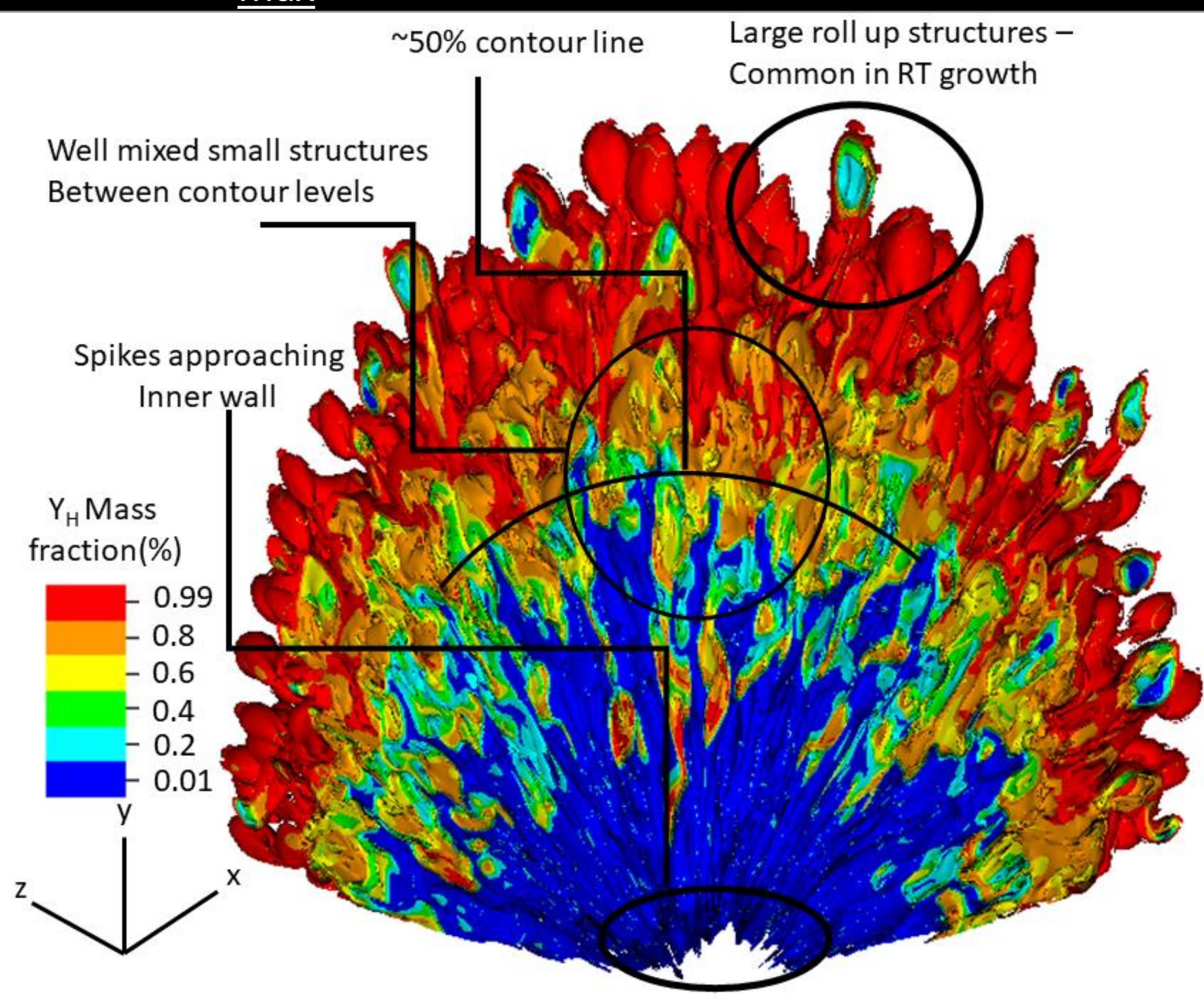


Project Goals

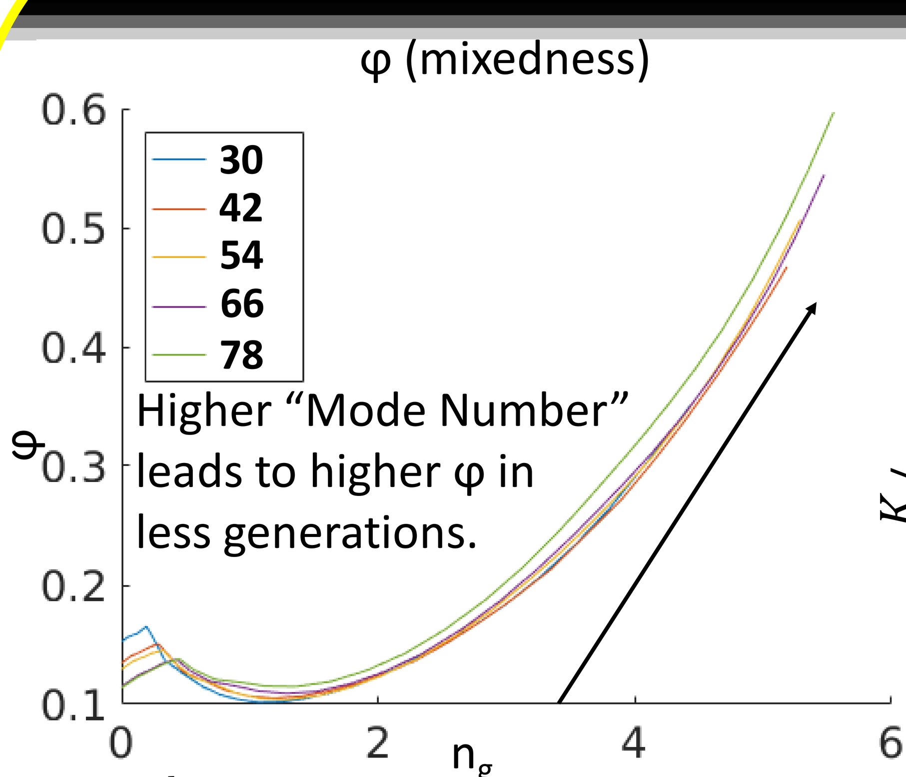
- Run high-fidelity 3D simulations of turbulent mixing using the ARES code
- Explore the parameter space involved in the RT instability in a converging geometry
- Find the key parameters to create a fully spherical 3D simulation to compare to previous planar work with intent towards publication

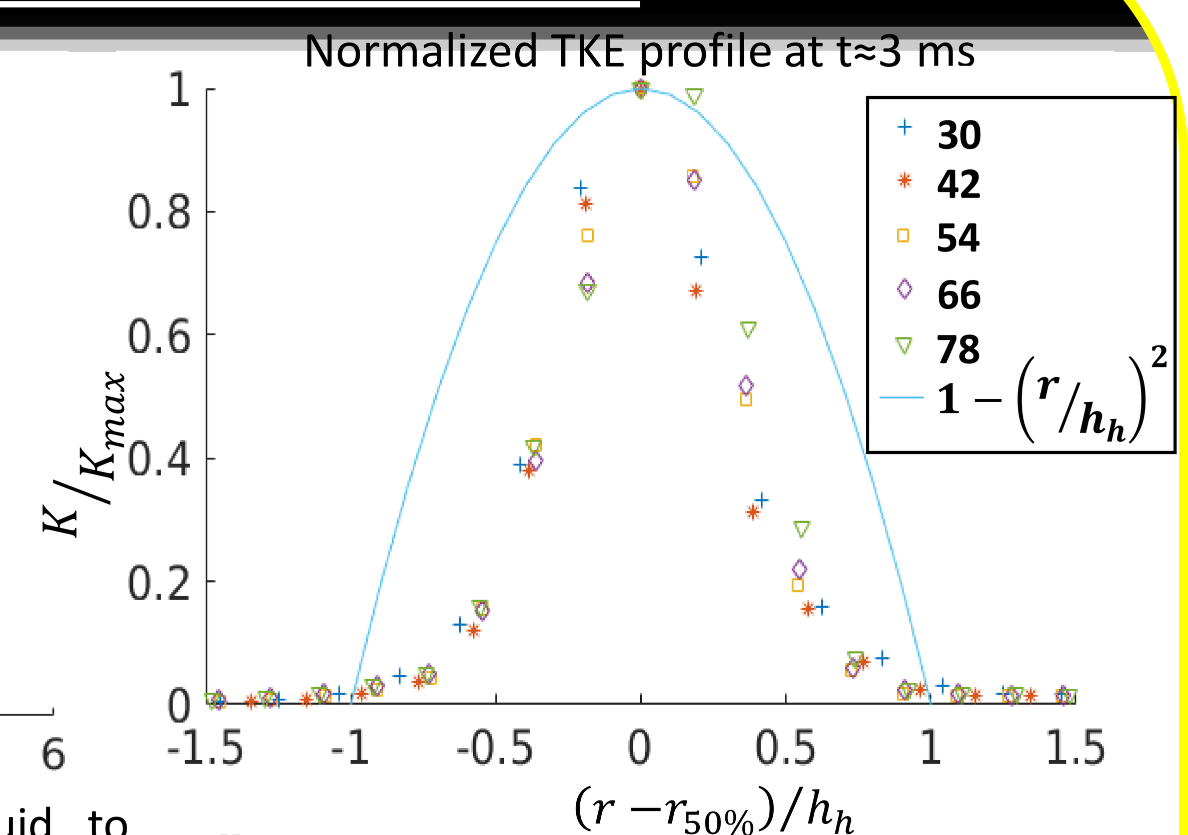
[1] Morgan, B. E., B. J. Olson, J. E. White, and J. A. McFarland. "Self-similarity of a Rayleigh–Taylor mixing layer at low Atwood number with a multimode initial perturbation." *Journal of Turbulence* (2017): 1-27.

L_{max} = 78 Late time Contour



Quantitative Results





- $\varphi = \frac{h}{h_h}$ The ratio of the mixed fluid to entrained fluid. Typically φ=0.8 corresponds to the mixing transition
- n_g (generations)$= log_2\left(\frac{h(t)}{h(0)}\right)$ a measurement of the mixing layer doubling
- The figure above shows that the lower modes grow faster in the linear region (A)
- It also shows use that the higher mode numbers approach turbulence faster

- $\frac{K}{K_{max}}$ The ratio of Turbulent Kinetic Energy to the maximum energy at that time
- $^{(r-r_{50\%})}/_{h_h}$ the non-dimensional length, the radius, r, minus the radius of the 50% contour, $r_{50\%}$, over the homogenous mixing width, h_h.
- Here the simulations all collapse to a single trend, which is compared to the analytic function $\left(\left(1-\left(^{r}/_{h_h}\right)^2\right)\right)$ which describes the RANS models ability to capture self-similarity.

Simulation Parameters

A parametric study was performed to explore the large parameter space important to the development of the RT instability. This study included adjusting both geometric and fluid properties. The data presented in this poster will cover a geometry parameter study, where the perturbation was varied. Other parameters are listed below in a table and can be discussed upon request.

- Spherical Harmonics: a function of L_{MAX} and L_{MIN}, this is the spherical analogue of the 1D Fourier series, where the L values can be thought of similarly to the mode number. This prescribes the perturbation across the interface, and as these values increase, the perturbation increases in frequency. It should be noted that the range between L_{max} and L_{min} was held at 12.
- Atwood number: $A_t = {}^{(\rho_H-\rho_L)}/_{(\rho_H+\rho_L)}$ Describes the hydrodynamic stability of the system
- Ratio: Describes the initial amplitude of the perturbation
- Resolution/AMR: Resolution describes the mesh while AMR describes how much the mesh is refined around the mixing layer. i.e.: per AMR level, the resolution increases by a factor of 3

Case	L_{MAX}/L_{MIN}
30	30/18
42	42/30
54	54/42
66	66/54
78	78/66

A_t	Ratio	Max dr (µm)	AMR levels
0.4	0.1	6.94	3

Conclusions and Future Work

- A parametric study was performed on the spherical harmonics. It was found that a higher mode number (greater L_{MAX}) tends towards turbulence faster both in time and in generations
- The mixedness plot shows an interesting trend in the linear regime, with the lower mode numbers exiting the linear regime earlier than the higher mode numbers. This trend is consistent within this data set and should be explored more thoroughly
- The TKE profile was plotted against the analytical function representing the RANS model and compared for self similarity. It was found that the RANS model over predicts the profile. All runs exhibit very similar profiles. This should be reconsidered again at late time- assuming there is no boundary interference.

- Future work will include stepping up the resolution for the higher mode simulations, experimenting with Atwood Number effects, and continuing simulations out past the mixing transition.
- Once the above work has been completed, a large scale high resolution full spherical configuration will be run and compared to the planar case

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